research & development

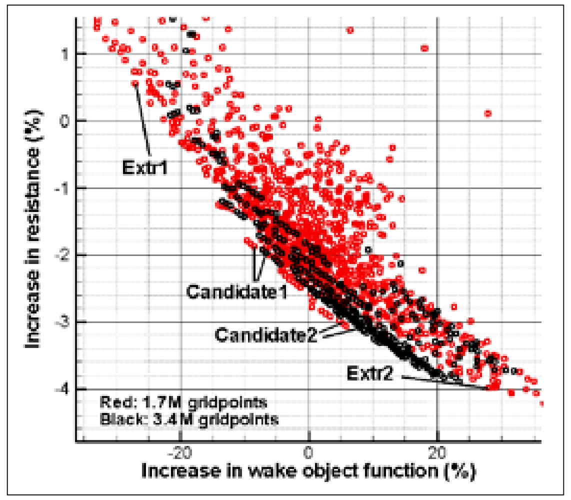

Figure 1: Pareto front

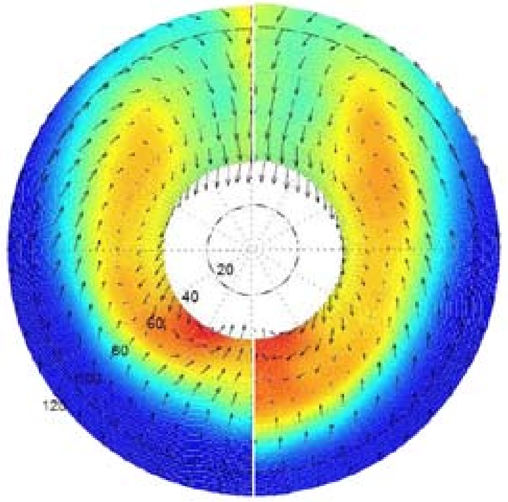

Figure 2: Measured wake.
Left: Optimized hull. Right: initial hull

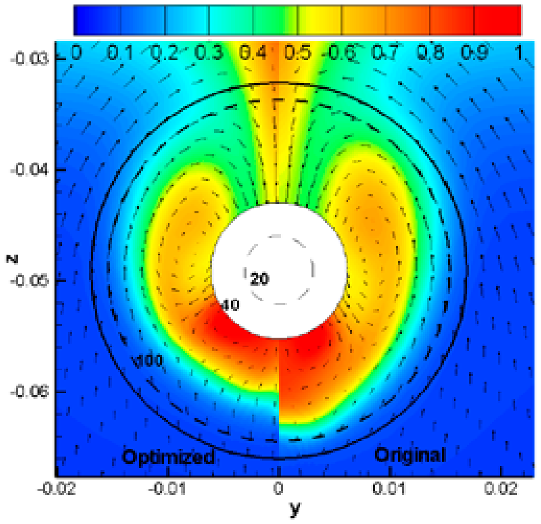

Figure 3: Computed wake.
Left: Optimized hull. Right: initial hull

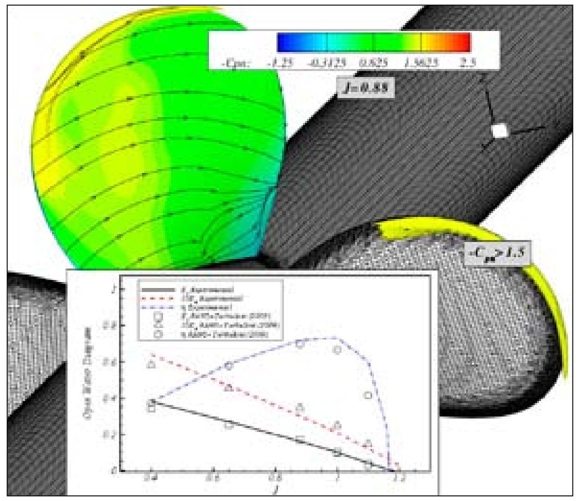

Figure 4: INSEAN E779A open-water computation by FreSCo.
(top) Pressure field, limiting-streamlines and iso-surface of -Cpn>1.5 for the advance coefficient of (J)=0.88. (bottom) Open-water diagram

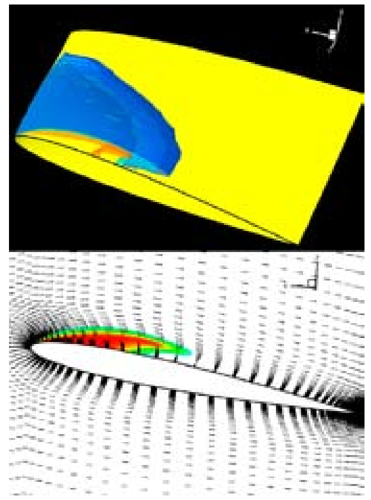

Figure 5: Delft-Wing computation by FreSCo.
(top) Iso-surfaces (0.25, 0.5, 0.90) of vapour illustrating the cavity-surface for one instant. (bottom) Vapour volume fraction distribution and velocity vector field for mid-section of the wing for the same instant

VIRTUE boosts the role of CFD in ship hydrodynamics

Ship resistance and propulsion are fundamental factors in the fuel efficiency of maritime transport. Modern computational techniques allow further improvements in that efficiency, by precisely predicting resistance and scale effects, computational optimisation for minimum resistance or power and by understanding and limiting propeller cavitation. The work of the 6th-Framework EU project VIRTUE has brought great progress on several fronts. Some highlights are discussed.

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In the Resistance and Propulsion work package, large improvements were made in the accuracy of resistance and wave-making computations and in the computation of scale effects [1]. Based on this, procedures for multi-objective optimisation of ship hulls were developed. The work culminated in a workshop in which five participants optimised the same tanker aftbody with respect to both resistance and wake field quality; using their own CAD system, hull form variation tool, grid generator and RANS code. At MARIN the GMS-Merge tool was used. This tool varies hull forms by a special interpolation between some pre-defined hull form variants. Deploying the tool was very effective. MARIN's ample experience meant that it was relatively easy to add new basis hull forms during the process. The flow computations were done using PARNASSOS. By using an internal network of computers hundreds of RANS computations could be done in just a few hours.

Figure 1 shows the increase of the resistance relative to the initial hull form on the vertical axis and the increase of the Wake Object Function (WOF) on the horizontal axis. Each point gives the computed values for one hull form variation. There is a clear envelope, a 'Pareto front', that indicates the best that can be achieved. A compromise between decrease of resistance and WOF is clearly required. This front is hardly influenced by the grid density, which lends much confidence to the results. From the submitted designs, MARIN's optimised hull form was finally selected as the most promising. A 3.1% reduction in viscous resistance was predicted, with an 8% sacrifice in WOF. A model has been built and measurements were performed at SSPA. A 3.4% decrease in viscous resistance and 11.5% increase in WOF were measured. The predictions were thus confirmed and also the qualitative change of the wake field agreed with these predictions (Figures 2 and 3).

The techniques that enable these systematic variations will now be further automatised. After trial applications, optimisation for the lowest resistance and best wake can be introduced to practical ship design.

Cavitation nuisance In the Propulsion and Cavitation work package, emphasis was placed on the development of tools for the prediction of cavitation nuisance: propeller induced pressure fluctuations and cavitation erosion. For a proper assessment of cavitation nuisance, an accurate prediction of the time-dependent cavitation volume is required. It has already been demonstrated that the lower blade-rate harmonics of the pressure fluctuations are effectively predicted by the potential flow panel code PROCAL. But for higher frequencies and for cavitation erosion risk assessments, more detail in the cavity behaviour is needed. Therefore, MARIN joined forces with its counterpart in Hamburg, HSVA, to develop a multi-phase, viscous flow CFD code called FRESCO. This code has been extensively tested and validated for more than four years, leading to a code that simulates the dynamic cavitation behaviour.
A review of the capabilities of multiphase RANS codes to address a cavitating propeller in a wakefield is given in [2].
In addition, exploratory propeller design exercises were carried out. Results clearly showed the importance of including pressure pulse and cavitation erosion constraints when aiming for the highest efficiencies. If these constraints are not included this will lead to unrealistically high efficiencies at unacceptable cavitation nuisance.

To meet the ever more stringent requirements on fuel reduction and exhaust emissions, MARIN plans to develop an integrated optimisation of an aftbody-propeller-rudder configuration. A detailed cavitation nuisance assessment is therefore, a necessary prerequisite. These FRESCO developments have come just at the right time.

1. Raven, H.C., van der Ploeg, A., Starke, A.R., and Eça, L., "Towards a CFD-based prediction of ship performance --- Progress in predicting resistance and scale effects", Int. Jnl of Maritime Engineering, Trans. RINA Vol.150 – A4, 2008.
2. Salvatore, F., Streckwall, H. and Van Terwisga, T., "Propeller cavitation modelling by CFD – Results from the VIRTUE 2008 Rome Workshop", First International Symposium on Marine Propulsors SMP'09, Trondheim, June 2009